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"MAINTENANCE OF TOPOLOGY USING CLUSTERING APPROACH IN AN MOBILE ADHOC NETWORKS"

DARSHANA H. PATEL[1] & ANJANA R. NAGARIA[2]

[1]Assistant Professor, Department of I.T, V. V. P. Engineering College, Rajkot, Gujarat, India

[2]Assistant Professor, Department of I.T, Sanjaybhai Rajyaguru College of Engineering, Rajkot, Gujarat, India

ABSTRACT

Efficiency of any adhoc network depends on the management of its moving nodes. Links between nodes are created and broken, as the nodes move within the network. As the movement of nodes is dynamic in MANET, to maintain the topology of such networks is the main issue. However, Topology Management can provide aid for the above challenging problem and is thus essential. Weeding out redundant and unnecessary topology information is usually called Topology Management.

There are two approaches to topology management in adhoc networks - Power Control and Hierarchical Topology Organization. Our focus is on Hierarchical topology control, with which a subset of the network nodes is selected to serve as the network backbone over which essential network control functions are supported. This approach to topology control is often called Clustering, and consists of selecting a set of cluster heads in a way that every node is associated with a cluster head.

A highly dynamic topology is a distinguishing feature of mobile adhoc network. Here, two clustering techniques Lowest ID[4] and CONID[5] has been implemented and their comparative study is carried out. To manage and update the topology, cluster structure is updated after fixed interval of time. Simulations are carried out using network simulator GLOMOSIM.

KEYWORDS: Adhoc Network, Topology Management, Power Control

INTRODUCTION TO MOBILE ADHOC NETWORK

Mobile adhoc network (MANET) is a wireless network of moving nodes which establishes connections with each other without any fixed infrastructure. MANET is capable of performing autonomous operation without any centralized administration. These are often called infrastructure-less networking since the mobile nodes in the network dynamically establish routing paths between themselves.

Working of Mobile Adhoc Network

Mobile Adhoc Network is shown in the figure 1. In this figure, total two mobile adhoc networks are shown. Moving sensor nodes are shown by square and wireless range of each node is shown by circle.

As we have described, mobile adhoc network does not have infrastructure and central authority. Here, in figure 1 nodes A through G are forming a network with no central authority. Each node can send and receive data from the node those are in its wireless range. Two out of range nodes establishes communication through intermediate nodes. Also, node F and node G communicates by hop to hop communication path from F-A-B-G.

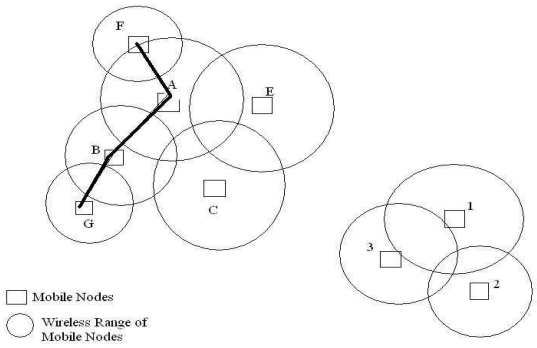

Figure 1: Mobile Adhoc Networks

Classification of Adhoc Network

Considering the parameter radio range or diameter, adhoc network can be classified into two ways namely: single-hop and multi-hop ad hoc network.

SINGLE HOP ADHOC NETWORK

As the name suggest, this is an adhoc network where nodes are within each other's radio range and thus has direct access to each other through wireless links. Because of the direct communication between every node, this network requires less complex protocols compared to multi-hop network for routing. Single-hop adhoc network is generally used for the short distance mobile communication. Typical applications of single-hop adhoc network are home network, office conference network etc where nodes are not widely spread.

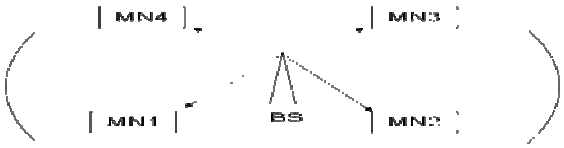

Figure 2: Single-Hop Adhoc Network [7]

MULTI HOP ADHOC NETWORK

While nodes are spread in the big area, multi-hop adhoc network is the solution for adhoc networking. Multi-hop adhoc network is the case where every node is far apart from the other and not in the direct radio range for communication. Due to unavailability of direct communication, this type of network relays on a multi-hop routing protocols. Multi-hop adhoc network is suitable for the scenario like battlefield, disaster recovery, investigation of digging, traffic networks.

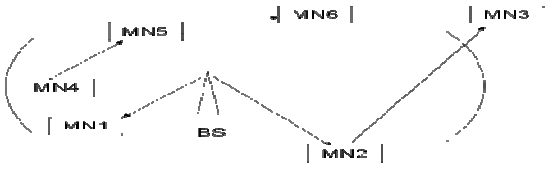

Figure 3: Multi-Hop Adhoc Network [7]

Characteristics of Manet

Characteristics of mobile adhoc network are self-organizing, multi-hopping, mobility, scalability, security, energy conversation, Topology maintenance etc which makes MANET suitable for up-coming needs while at the same time adds complexity to the protocols to be design.

MOTIVATION

Ad hoc networks do not use any fixed architecture for communication. In such type of network, the application may be mobile, the environment may change dynamically and the interconnections between nodes may change on a continual or arbitrary basis. Nodes of the MANET are mobile so changes in topologies are frequent and it introduces a requirement of dynamic topology management.

In order to provide efficient communication there is a need for Topology Management. Weeding out unnecessary and redundant topology information is called Topology Management. This is a quite challenging and vital issue due to the characteristics (e.g., node mobility, the battery power and other resource), of MANET. There are two Approaches for Topology Management: (1) Power Control and (2) Hierarchical Topology Organization (or Clustering).

- **Power Control**

Power Control approach adjust the transmit power in such a way that overall network connectivity is ensured. However, harmful interface is created due to different transmission power among the one-hop neighbors.

- **Hierarchical Topology Management (Clustering)**

In this approach, network is divided into clusters. Every cluster has a cluster-head. Every cluster head has information about members of its cluster. Every node is aware of which cluster it belongs to. Nodes in different clusters can communicate through their cluster heads. With this kind of network organization, it is not necessary for every node to store the routes to all the nodes. Thus, storage space is saved. Even every node need not be involved in route update procedure. As in topology is dynamic in MANET, clusters also continuously change. We have focused on clustering approach in this work. Our work is a comparative study of two different clustering schemes - LOWEST ID [4] and CONID [5].

Tool Used

Because of complex nature of the MANETs, their simulation is a very challenging issue. The Simulator Tool used is Global Mobile Information System Simulator (GloMoSim). GloMoSim uses PARSEC which is a PARallel Simulation Environment for Complex systems. It is a C-based discrete-event simulation language.

WHAT IS TOPOLOGY MANAGEMENT?

All the nodes in a network maintain certain information for essential purposes such as routing, broadcasting etc. Periodic collection of Topology information becomes quite difficult and complicated due to dynamic nature of mobile node. But Topology Management or Control approach eases the above task since it collects only the information which is necessary. Thus, Weeding out unnecessary and redundant topology information is called Topology Management.

Différent Topology Management Techniques

There are two approaches to Topology Management in adhoc networks: Power control and Hierarchical topology organization [2]. In Power control technique, overall network connectivity is ensured by adjusting the power on the individual node basis. In such situations, one seeks to employ per packet power control depending on the source and destination of the packet. This gives rise to a problem which involves power control. However, topology derived from power control schemes often creates harmful interface due to the different transmission ranges among one-hop neighbours [1,2]. So, our work focuses on hierarchical topology control, with which a subset of the network nodes is selected to serve as the network backbone. This approach to topology control is often called CLUSTERING, and consists of selecting a set of cluster heads to control the topology. Once elected, the cluster heads help to reduce the complexity of maintaining topology information.

CLUSTERING IN AN ADHOC NETWORK

In a clustering scheme, the mobile nodes in a MANET are divided into different virtual groups, and they are allocated geographically adjacent into the same cluster according to some rules [6]. A typical cluster structure is shown in Figure 4. In most clustering techniques, nodes are selected to play different roles according to a certain criteria. In general, three types of nodes are defined:

Ordinary Nodes: Ordinary nodes are members of a cluster which do not have neighbours belonging to a different cluster.

Gateway Nodes: Gateway nodes are nodes in a non-cluster head state located at the periphery of a cluster. These types of nodes are called gateways because they are able to listen to transmissions from another node which is in a different cluster. To accomplish this, a gateway node must have at least one neighbour that is a member of another cluster.

Cluster Heads: Most clustering approaches for mobile ad hoc networks select a subset of nodes in order to form a network backbone that supports control functions. A set of the selected nodes are called cluster heads and each node in the network is associated with one. Cluster heads are connected with one another directly or through gateway nodes. The union of gateway nodes and cluster heads form a connected backbone. This connected backbone helps simplify functions such as channel access, bandwidth allocation, routing power control and virtual-circuit support [6].

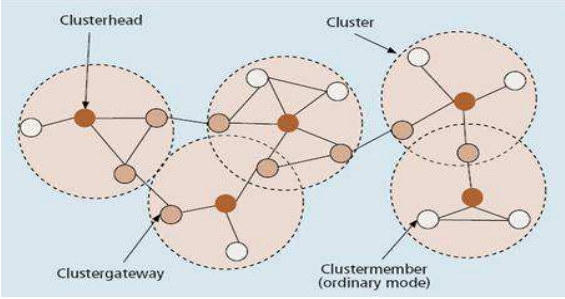

Figure 4: Cluster Structure Illustration [6]

Importance of Clustering Approach

However, a Flat structure encounters scalability problems with increased network size, especially in the face of node mobility at the same time. This is due to their intrinsic characteristics. Consequently, à Hierarchical architecture is

essential for achieving a basic performance guarantee in a large-scale MANET. Since a Cluster structure is a typical hierarchy, focus is on presenting an effective and efficient clustering scheme for MANETs.

Clustering is an important research topic for mobile ad hoc networks (MANETs) because clustering makes it possible to guarantee basic levels of system performance, such as throughput and delay, in the presence of both mobility and a large number of mobile terminals. Also, clustering helps to aggregate the topology information since the number of nodes in the cluster is smaller than the number of nodes in the entire network. Hence, it makes the network easily manageable by making it connected. Clustering is useful to maintain the topology of the network. The efficiency of a communication network depends not only on its control protocols, but also on its topology.

Clusterhead Selection Schemes

Depending on the parameters used for the selection of cluster head which controls the cluster structure, different criteria and schemes exists. But our focus is on the below two schemes:

Lowest ID

Highest Connectivity or Degree

Lowest Id Clustering Algorithm

The Lowest-ID [4] clustering is one of the most popular clustering schemes used in the old as well as recent ad hoc networks literature. The Lowest-ID algorithm proceeds as follows.

Step 1: Unique ID is assigned to each node.

Step 2: Broadcast the ID of each node to the list of its neighbours (including itself).

Step 3: The node that has the lowest ID relative to its neighbours is selected as cluster-head.

Step 4: A node is assigned as cluster-gateway if it can hear from two or more cluster heads and as cluster-member if it is a neighbour to a cluster head.

Conid (Connectivity ID) Clustering Algorithm

In order to select cluster heads by CONID [5], connectivity is considered as a first criterion and lower ID as a secondary criterion. Using only node connectivity as a criterion causes numerous ties between nodes On the other hand, using only a lower ID criterion generates more clusters than necessary.

Step 1: Each node in the network is assigned a pair did = (d, ID). d is a node's connectivity and ID is the node's identifier.

Step 2: A node is selected as a cluster head if it has the highest connectivity. In case of equal connectivity, a node has cluster head priority if it has lowest ID.

IMPLEMENTATION

Implementation of Lowest ID and CONID clustering algorithm is done using GloMoSim Simulator. Formation of cluster is done according to the parameter selected and to maintain the cluster, the network structure is updated at 1 minute interval. Simulation Parameters are listed in below Table

Table 1

Simulation Area	2000x2000 meters
No. of Nodes	50,100,150,200,250
Node Placement	Random
Mobility Model	Random Way Point
Mobility Min-Max Speed	0-5(meters/second)
Simulation Time	10 minutes
Propagation-Limit	-111.0 dBm
Radio-TX-Power	15.0

Performance Metrics

- **Graph 1:** Comparison of Lowest ID CONID using 1-hop neighbor.

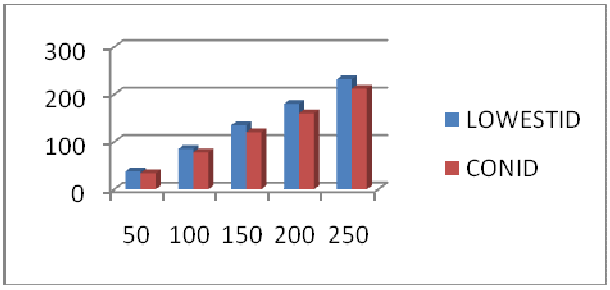

Figure 5: No of CH Formed v/s. No of Nodes Using 1-Hop Neighbor for: 1) Lowest ID and 2) CONID

Comparing Lowest ID and CONID schemes, more number of CH are formed in Lowest ID as it takes only single parameter into consideration while selecting the cluster head i.e. ID Whereas, CONID approach considers the Connectivity as first parameter then ID as second. Thus, this combined consideration reduces the number of cluster-head in CONID compared to LOWEST ID.

- **Graph 2:** Comparison of Lowest ID and CONID using 2-hop neighbor.

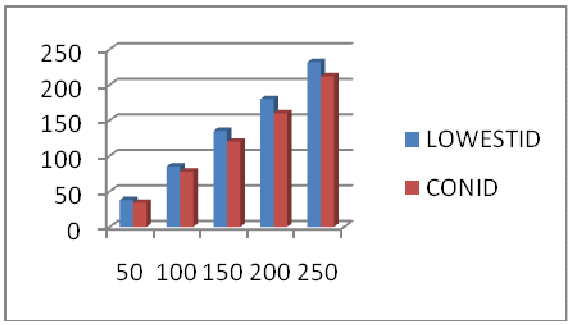

Figure 6: No of CH Formed v/s. No of Nodes Using 2-Hop Neighbor for: 1) Lowest ID and 2) CONID

It is observed from the figure 6, that the number of cluster head increases as the number of nodes increases. Here, the nodes are considered to be two-hop away from each other. Also, more number of leading nodes obtained in CONID are less in number than Lowest ID.

- **Graph 3:** Comparison of 1-hop and 2-hop neighbor using Lowest ID clustering scheme.

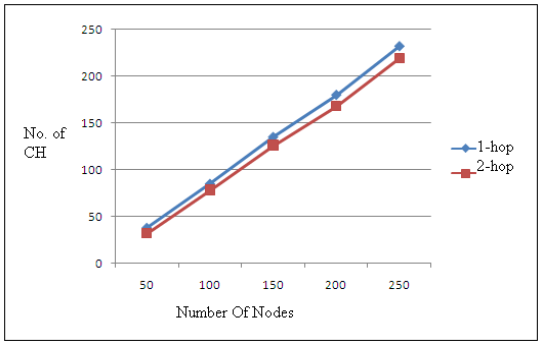

Figure 7: Comparison of 1-Hop and 2-Hop Neighbor Using Lowest ID

From the above Figure 7, it is clear that no. of leading nodes or Cluster head is considerably decreased in 2-hop neighbor compared to 1-hop neighbor. This is because one-hop neighborhood considers only adjacent or direct neighbors whereas two-hop neighborhood considers also the neighbors of direct neighbor. Note that the clustering scheme considered is Lowest ID and as the number of nodes increases, the leading nodes also increases in both 1-hop and 2-hop neighbor.

- **Graph 4:** Comparison of 1-hop and 2-hop neighbor using CONID clustering scheme.

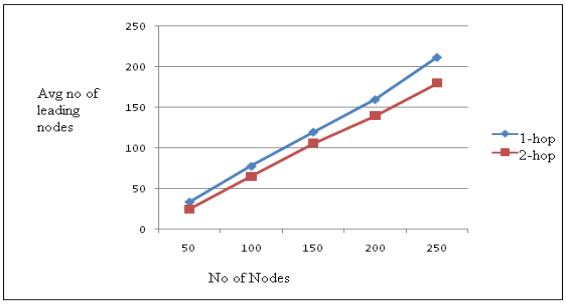

Figure 8: Comparison of 1-Hop and 2-Hop Neighbor Using CONID Clustering Scheme

From the above Figure 8, it is clear that no. of leading nodes or Cluster head is considerably decreased in 2-hop neighbor compared to 1-hop neighbor. Note that the clustering scheme considered is CONID and as the number of nodes increases, the leading nodes also increases in both 1-hop and 2-hop neighbor.

CONCLUSIONS AND FUTURE WORK

Topology Management in adhoc network is a quite challenging and vital issue due to the characteristics (e.g., node mobility, the battery power and other resource), of MANET. In this work, we have focused on management of topology in adhoc network using Clustering approach.

Thus, we conclude the followings:

- As the number of nodes increases, the leading nodes also increases but these leading nodes are found to be less in CONID compared to Lowest ID clustering scheme. (b)The number of Cluster heads is decreased when clustering is done considering the 2-hop Neighbors rather than 1-hop neighbor in both Lowest ID and CONID.

The work done can be extended further as follows:

- Other Clustering Schemes consisting of more refined parameters can be considered for selection of CH for better results. (b)Also, one of the application of Topology Management like efficient Routing can be implemented further.

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